Colliding laser produced plasmas analysis: fast imaging and spectroscopic study

Domagoj Kos[1,2], O. Maguire[1], F. O'Reilly[1], P. Dunne[1], E. Sokell[1]

1. School of Physics, University College Dublin, Belfield, Dublin 4, Ireland
2. Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehova 7,511519 Praha 1, Czech Republic

- Two laser produced plasmas that expand close to each other collide and can form a stagnation layer[1]
- Splitting of a laser pulse using wedge prism creates two single plasmas with few mm separation
- Kinetic to thermal energy transfer in the stagnation layer leads to reheating of the ions in the stagnation layer[2]
- The dynamic properties of the stagnation layer are different to the properties of the single laser produced plasma[3]

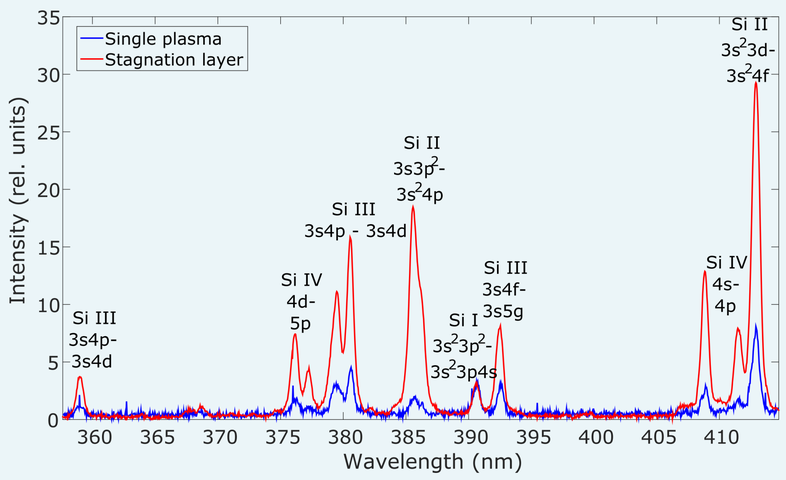


Figure 1: 10 ns integration time spectrum for single Si plasma and stagnation layer 150 ns after laser pulse

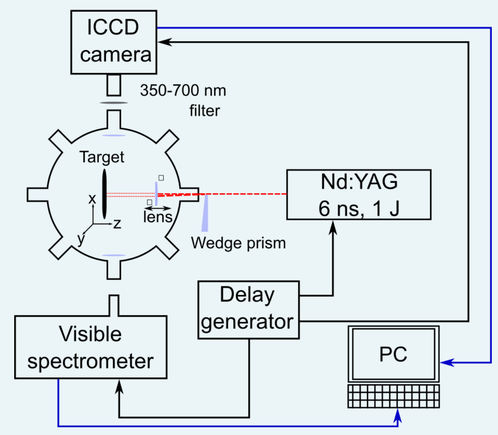
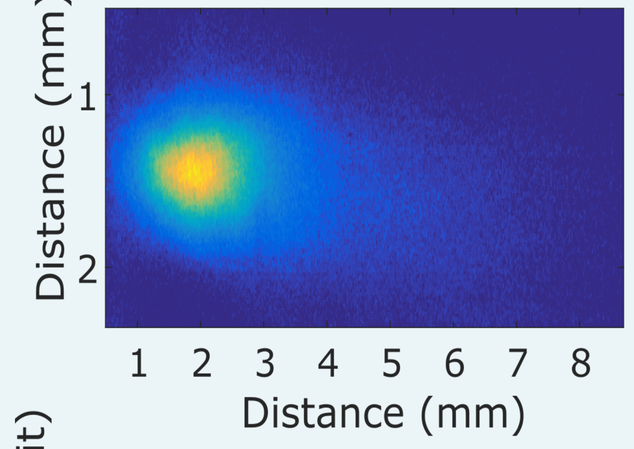


Figure 2: Experimental setup scheme



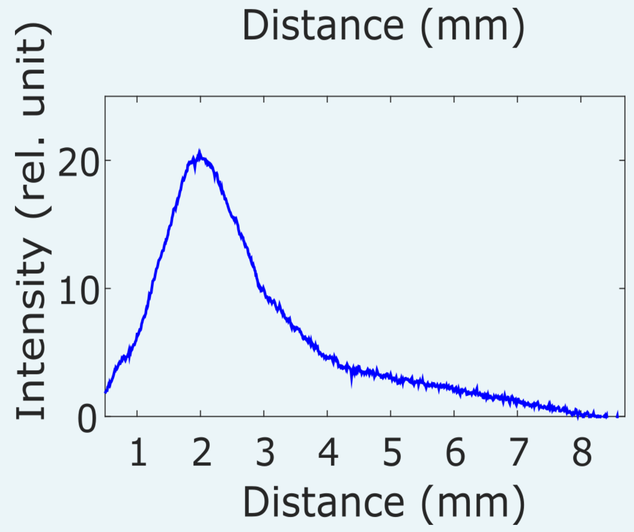


Figure 3: Visible emission from Si stagnation layer 150 ns after laser pulse and cross section through the image above

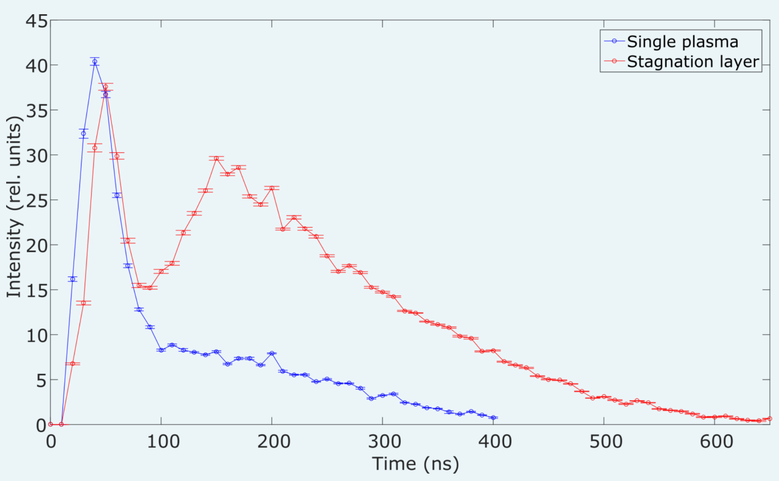


Figure 4: Si II line intensity evolution comparison For a single plasma and the stagnation layer

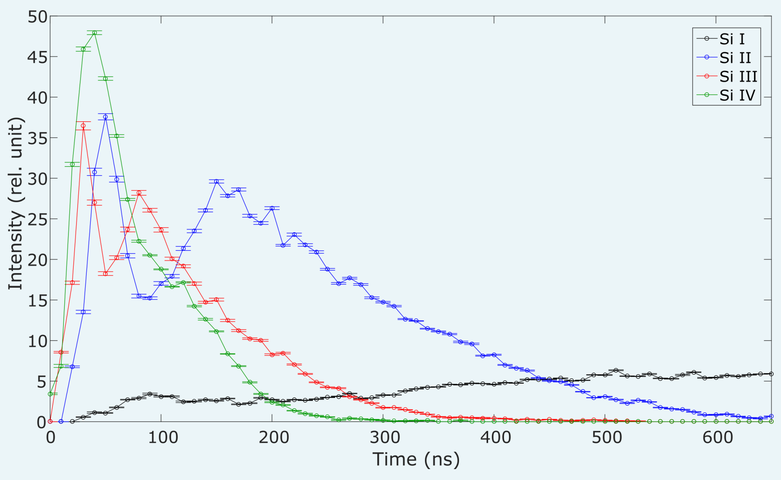


Figure 5: Maximum line intensity for different ion species lines in the stagnation layer

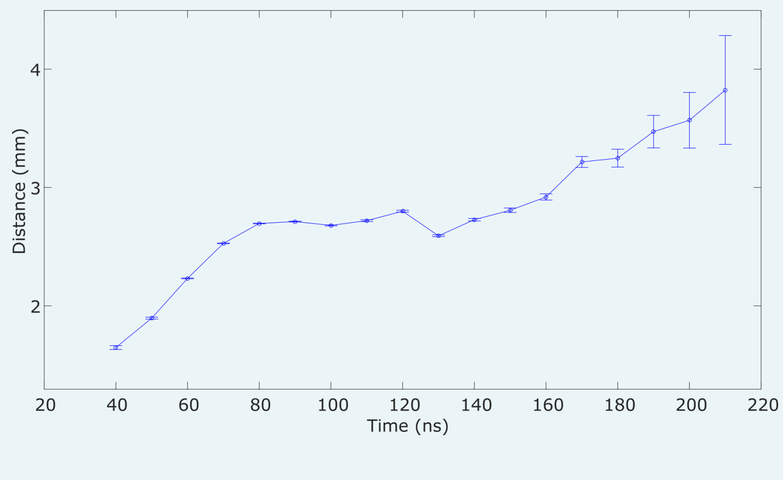


Figure 6: Distance of plasma front of Si stagnation layer from the target

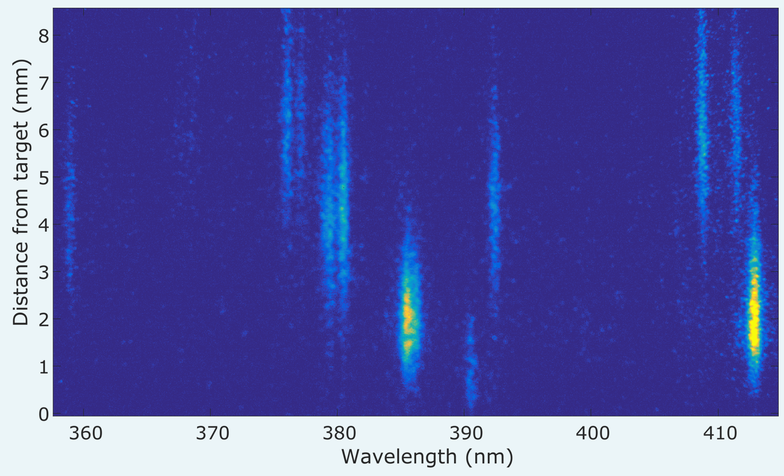


Figure 7: Example of 10 ns spectrally resolved image on the CCD, 150 ns after laser pulse

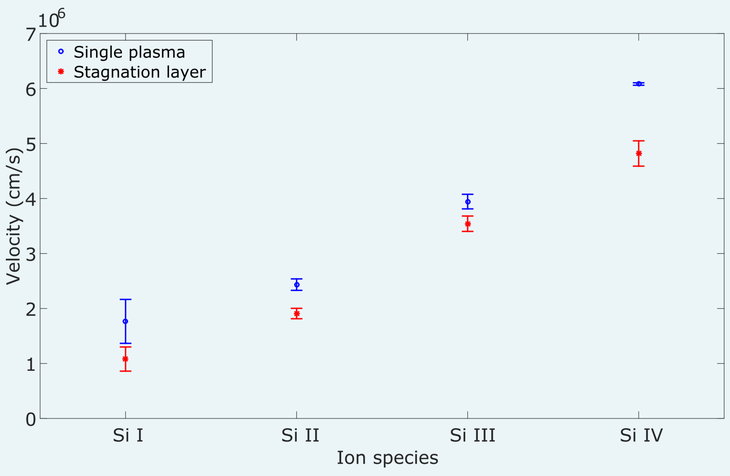


Figure 8: Si ion species velocities determined from the spectra of single plasma and the stagnation layer

- For single Si plasma ion emission stops after 400 ns
- Colliding Si plasma ion emission is present for more than 600 ns
- Additional ionisation of Si II to Si III occurs in the stagnation layer 100 ns after the laser pulse (τ=6 ns)
- The reduction of ion species velocities in stagnation layer agrees with kinetic to thermal energy transfer hypothesis
  - ❖ Velocity reduction is not recorded for Pb plasma

domagoj.kos@ucdconnect.ie

1. P. Rambo, "Time-implicit fluid simulation of collisional plasmas", J. Comput. Phys. 98(2), 317–331 (1992)
2. P. Chenais-Popovics, "Kinetic to thermal energy transfer and interpenetration in the collision of laser-produced plasmas", Phys. Plasmas 4(1), 190–208 (1997).
3. P. Yeates, "Atomic mass dependent electrostatic diagnostics of colliding laser plasma plumes", Phys. Plasmas 20(9), 093106 (2013).